AMENDMENTS TO THE SPECIFICATION

Please replace entire specification with the following amended specification:

Method and Apparatus for Web-based Storage On Demand

~~**IP Based Distributed Virtual SAN**~~

~~By~~

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~~8/1/2002~~

~~**Field of the Invention**~~

~~This invention is the continuation of the previous invention, application number 60/401,238, of "Concurrent Web-based Multi-Task Support for Control Management System", which focus on web based multi-tasking support for web-console in the central controlled distributed scalable virtual machine environment. The present invention focus on distributed IP SAN based storage service and other distributed services in the central controlled distributed scalable virtual machine environment. It relates generally to IP based out-band accessed distributed virtual SAN infrastructure, its automatic configuration, its storage volumes allocation and accessing services. This invention also presents the applicability of the principles of IP based distributed virtual SAN service to other services and applications in a similar environment.~~

FIELD OF THE INVENTION

The present invention generally relates to computer communications network. More specifically, the present invention relates to web based data storage systems.

BACKGROUND OF THE INVENTION

~~**Background Information**~~

~~**a) Terminology:**~~

~~**CCDSVM:**~~

~~It is an abbreviation for central controlled distributed scalable virtual machine system. The CCDSVM allows a control management station to control a group of systems and provide distributed services to client system in Intranet and Internet as well as in LAN environment.~~

~~**Storage Media:**~~

~~Storage media includes magnetic hard disk drives, solid state disk, optical storage drive, and memory card etc.~~

~~**Storage Connection and Control Media:**~~

~~Storage connection and control media includes controller of IDE, SCSI, Fibre optical, Ethernet, USB, or may be wireless media and all related cables etc. Each controller of storage media such as Raid, IDE, or SCSI controller may control multiple storage media drives on a system.~~

~~**Storage System:**~~

~~Storage system includes one or more storage media and the storage connection and control media. Storage system also contains related software modules to deliver storage services.~~

~~**SAN:**~~

~~SAN stands for storage area of network. It is a storage system, which provides computer host with block data service through storage connection media, such as Fibre-optical cable, Ethernet cable or other media by using protocol based on IP, non-IP based such as Fibre-Channel, or others. IP SAN uses IP based protocol to provide storage raw block data services. All discussion of SAN in this invention are within the scope of a model of central controlled distributed scalable virtual machine (CCDSVM).~~

~~**DNS:**~~

~~It stands for domain name server of network technology, which is a Internet software infrastructure. It helps any system on the net to find its peer target system's network address in order to send the message to its peer system.~~

~~**SNMP:**~~

~~An abbreviation for "Simple Network Management Protocol", which is a standard Internet protocol. The SNMP trap is a UDP packet sent by SNMP daemon on a SNMP agent system to SNMP network management station through network link.~~

~~**b) Figures:**~~

~~1) Distributed Virtual SAN Infrastructure.~~

~~2) The Actual Components of Distributed Virtual SAN.~~

~~3) Virtual SAN Automatic Configuration Protocol.~~

~~4) Virtual SAN Auto Configuration Protocol Packet format.~~

~~5) Example of Storage Volume Information of an IP SAN Unit.~~

~~6) A Hypothetical Example of Storage Volume Requests and Assignment.~~

~~7) Direct Attached Storage System.~~

~~8) In-Bound Accessed Virtual Storage System.~~

~~9) A Simplified Diagram of Central Controlled Distributed Scalable Virtual Machine System.~~

~~10) A Simplified Diagram of Disaster Recovery Scheme of Distributed Virtual SAN Infrastructure.~~

~~In the drawing, like elements are designed by like reference numbers.~~

~~Brief Description of the Invention~~

Today's corporate IT professionals typically face [[faces]] many challenges to handle the ever increasing information and data. ~~This often requires many~~ To handle large amount of data, many organizations [[to]] expand their storage capacity by employing[[,]] manage storage systems locally in order to maintaining their ~~and to keep the~~ normal business [[run]] operating. A conventional approach is to use ~~Currently, The~~ IP based network attached storage ("NAS"), which ~~(network attached storage)~~ effectively provides data storage and services for end users~~'s file system needs~~. Moreover, ~~On the other hand,~~ at the enterprise level, the majority storage systems are ~~still server~~ directly attached or connected to server(s) or host(s) as shown in Figure 7. These server(s) and/or host(s) are typically used ~~(Fig. 7) and being accessed~~ as raw block data devices through conventional communication connection media, such as [[either]] traditional IDE, SCSI, Fibre Channel, or [[may be]] Ethernet.

The server, which is directly [[direct]] attached to a storage system as illustrated in FIG. 7 typically ~~(Fog. 7)~~ has many drawbacks, which are described as following:

a) ~~Currently, the most advance~~ a typical conventional storage management system is only capable of handling ~~to handle~~ 4TB (terabytes) of data, which is ~~far from~~ usually not good enough for a typical enterprise storage management system; ~~requirement.~~

b) The most of servers, which are directly attached to storage systems, have [[has]] problems for further expanding their storage ~~to expand its~~ capacity. For example, ~~In some case,~~ it may require to purchase new servers ~~is quite often to require purchasing a new server~~ in order to increase ~~expand the~~ storage capacity;~~. In other cases, it also requires to shutdown the server and to stop the normal operation in order to expand the storage capacity.~~

c) The storage being attached to a server can only be accessed by the attached server and can not be shared by other servers even if [[a]] server's storage availability is not evenly distributed across all servers within ~~has spare capacity left while other server are in shortage of the storage capacity within a department or cross department in~~ a organization[[.]];

d) Each attached storage system has to be managed separately and this is a nightmare for IT professionals;[[.]]

e) With the attached storage system, the backup/restore has to go through the data network, this will tax or reduce the [[data]] network performance;[[.]]

f) [[The]] a typical SCSI connection only allows a 12-meter distance for data accessing with 15 storage devices. Similarly, [[while]] Fibre Channel is [[also]] limited to 10 kilometers communication distance ~~long~~. Distance limitation [[This]] effectively prevents them from being the best choice for disaster recovery of the storage system[[.]]; and

g) The Fibre Channel based storage system cannot handle well for the interoperability. Also, Fibre Channel based storage system is expensive to build and to maintain.

Figure 8 shows ~~There is~~ a conventional type of virtual SAN, which is in-band controlled and accessed ~~(Fig. 8),~~ with which the data path from hosts (1 of Fig. 8) to the SAN units (4 of Fig. 8) going [[goes]] through virtual SAN control management station (2 of Fig. 8). It is not efficient in term of accessing the data by the hosts because ~~due to~~ the virtual SAN control management station can easily be a performance bottleneck. Similarly ~~By same reason~~, the scalability of this type of virtual SAN [[also]] is poor.

SUMMARY

With [[the]] rapid development of high speed communication technology, the problems mentioned above can be solved by an IP based out-band accessed distributed virtual SAN infrastructure (Fig. 1) of this invention. With this invention, each host[[s]] (1 of fig. 1) can directly access IP based SAN units (4 of Fig. 1) without going through control management station (3 of Fig. 1). The IP based out-band accessed distributed virtual SAN infrastructure (Fig. 1) actually represents an example of central controlled distributed scalable virtual machine system (CCDSVM) (Fig. 9). Wherein, each system units actually is a SAN unit (4 of Fig. 1), specifically is an IP based SAN unit.

With this invention, each SAN unit (4 of Fig.1) can be accessed by one or more hosts (1 of Fig.1) and each host[[s]] can access one or more SAN units (Fig. 6). In addition, the storage accessing goes directly through communication link (2 of Fig. 1) between hosts (1 of Fig. 1) and SAN units (4 of Fig. 1) without involvement of the control management station (3 of Fig. 1). Further, the SAN units (4 of Fig. 1) can be dynamically added without interrupting normal data accessing from hosts (1 of Fig. 1) and [[they]] are controlled, monitored, and managed by a control management station (3 of Fig. 1) through a management console (10 of Fig. 1). The control management station (3 of Fig. 1) may also accept storage volume/partition requests from each host[[s]] (1 of Fig. 1), and assign the

matched volumes/partitions of SAN units (4 of Fig. 1) to these hosts. Therefore, each host[[s]] (1 of Fig. 1) could directly access the right volumes/partitions of assigned SAN units without [[goes]] going through the control management station again.

This invention will become understood with reference to the following description, claims, and accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given below and from the accompanying drawings of various embodiments of the invention, which, however, should not be taken to limit the invention to the specific embodiments, but are for explanation and understanding only.

Figure 1 illustrates a distributed virtual storage area of network ("SAN") infrastructure in accordance with one embodiment of the present invention;

Figure 2 illustrates actual Components of Distributed Virtual SAN in accordance with one embodiment of the present invention;

Figure 3 illustrates Virtual SAN Automatic Configuration Protocol in accordance with one embodiment of the present invention;

Figure 4 illustrates a Virtual SAN Auto Configuration Protocol Packet format in accordance with one embodiment of the present invention;

Figure 5 illustrates an Example of Storage Volume Information of an IP SAN Unit in accordance with one embodiment of the present invention;

Figure 6 illustrates a hypothetical example of Storage Volume Requests and Assignment in accordance with one embodiment of the present invention;

Figure 7 is a conventional Direct Attached Storage System;

Figure 8 is an In-Bound Accessed Virtual Storage System;

Figure 9 illustrates a Simplified Diagram of Central Controlled Distributed Scalable Virtual Machine System in accordance with one embodiment of the present invention; and

Figure 10 illustrates a Simplified Diagram of Disaster Recovery Scheme of Distributed Virtual SAN Infrastructure in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION ~~Description of Drawings~~

The following terms are used through out this patent application to describe the present invention. A central controlled distributed scalable virtual machine ("CCDSVM") system allows a control management station to control a group of systems and to provide distributed services to client systems over the Intranet, Internet, and/or LAN environment. Storage media includes magnetic hard disk drives, solid state disk, optical storage drive, and memory card etc. Storage connection and control media may include controller of IDE, SCSI, Fibre optical, Ethernet, USB, or wireless media, and/or other related cables etc. Each controller of storage media such as Raid, IDE, or SCSI controller may control multiple storage media drivers on a system. Storage system includes one or more storage media devices, storage connections, and/or storage media controllers. Storage system also contains related software modules for delivering storage services.

Storage area network ("SAN") is a storage system that is capable of providing block data services to various computer hosts through storage connection media, such as Fibre-optical cable, Ethernet cable or Internet Protocol ("IP") based connection media protocol or non-IP based connection media protocol. The non-IP based connection media protocol, in one example, includes Fibre-Channel. IP SAN uses IP based protocol to provide storage raw block data services. All discussions of SAN in this invention are within the scope of a model of central controlled distributed scalable virtual machine ("CCDSVM").

DNS stands for domain name server of network technology. DNS is an Internet software infrastructure and is capable of identifying network addresses for its peer systems. For example, the network addresses may be used to communicate with the peer systems. A Simple Network Management Protocol ("SNMP") is a standard Internet protocol. A SNMP trap is a user datagram protocol ("UDP") packet, which may be used to send the SNMP daemon on a SNMP agent system to a SNMP network management station via network links.

Fig. 1[[: Shows]] shows an example of a simplified block diagram of IP based out-band accessed distributed virtual SAN infrastructure. The distributed virtual SAN infrastructure ~~, which~~ includes multiple hosts (1), network infrastructures (2), a control management station (3), virtual storage pool (11) having multiple IP SAN units, and a management console (10). In one embodiment, each host (1):

~~a) Hosts (1):~~

~~It~~ contains service software modules ~~(~~9 ~~of Fig. 1)~~. The service software modules (9) are configured to communicate with a control management software module (7) of a control management station (3) for storing ~~to get storage~~ information on a specific IP SAN unit (4). It also communicates with service software modules (6) of IP SAN unit (4) to retrieve a [[get]] block of data from SAN units (4 ~~of Fig. 1~~). The service software modules (9) can be coded or implemented with any suitable programming languages such as C, C++, Java or

others. The service software modules (9) may also ~~and can~~ use any suitable protocols such as IP based or non-IP based ~~or other~~ protocols.

The host (1), in one embodiment, could be ~~any system such as~~ a server, a desktop, [[or]] a laptop PC, etc., which needs to access a block data storage. The spare host (12 ~~of~~ ~~Fig. 1~~) represents a part of recovery scheme that could be implemented in a CCDSVM environment.

~~b) Network infrastructure (2):~~

~~It represents~~ Network infrastructure (2) can be any kind of communication links, which could be [[either]] a department LAN, a corporate intranet, an Internet infrastructure or others. In one embodiment, network infrastructure (2) includes ~~It consists~~ switches, routers, gateways, cables (Ethernet, optical Fibre, ~~and others~~), wireless communication media, or others. The network infrastructure (2) provides data path between hosts (1), distribute control management station (3), and SAN Units (4). The network infrastructure (2) also includes software infrastructure such as DNS or DHCP ~~or others to~~ for facilitating ~~help~~ ~~each~~ systems on the net to identifying ~~find the~~ target addresses, which are used for sending or receiving data within a network domain or in a cross-domain network environment.

~~To simplify the discussion, when describing send a message from a system A to a system B, it will simply implied that the~~ It should be noted that DNS and/or other Internet address identification mechanism may be used when a message or data stream is sent from a system A to a system B~~is used~~. In addition, the message is sent ~~is send~~ from source system A to target system B via communication link of this network infrastructure.

~~c) Control management station (3):~~

~~It~~ Control management station (3) includes distributing control management software modules (7) and console support software modules (8). To support web-based console, it ~~must have~~ requires the web server software (15). The distribute control management

software modules (7) communicate with service modules (6) of IP SAN units (4) to retrieve [[get]] storage information for constructing a virtual SAN storage pool (11). The communication between distributed control management software modules (7) and service modules (6) of IP SAN units (4) is further configured [[,]]] to monitor IP SAN unit, and to perform various system operations, which include[[s]] storage configuration and partitioning etc. The control management software modules (7) [[It]] also communicates with service software modules (9) of host (1) for distributing storage volumes to each hosts (1). The distribute control management software modules (7) can be implemented with any suitable programming languages such as C, C++, Java, XML, etc. The communication protocols ~~used by distribute control management software (7)~~ between control management station (3) and IP SAN units (4) could be any suitable IP based protocols. The communication between control management station (3) and hosts (1) can be any suitable IP base or non-IP based ~~or other~~ protocols.

The console support software modules (8) employ inter-process communication mechanism to obtain [[get]] information relating to ~~of the~~ IP SAN units (4) from the distributed control management software modules (7) ~~through inter-process communicate mechanism~~. The console support software modules (8) [[It]] further provide[[s these]] information to web server software (15) through the inter-process communication mechanism. The console support software modules (8) can be implemented with any suitable programming languages such as C, C++, Java, XML, etc.

The web server software (15) communicates with management console software (10) on console host (14) through web protocol such as HTTP. The web server software (15) is configured to provide ~~end user~~ a centralized storage management capability within the [[for]] entire distributed virtual SAN infrastructure for any end user over a network. The web server software (15) could be ~~an existing~~ commercially available software or other proprietary software.

To simplify foregoing discussion, the communication path mentioned above will be simply referred to as console support software modules (8), which communicate (send/receive) with management console (10) on console host (14) (without further mentioning the role and function of web server software (15) on control management station).

In addition, to support non-web based console, ~~there is no needs of~~ web server software (15) on control management station (3) is often not required. In this case, the console support software modules (8) could communicate with management console software (10) with a suitable protocol other than a web protocol such as HTTP.

~~d) IP SAN Units (4) and Virtual Storage Pool (11)~~

The virtual storage pool (11) includes multiple IP SAN units (4), wherein each IP SAN unit further includes service modules (6). The IP SAN units (4) further contain[[s]] storage media, storage communications and control media. The storage hardware media of each IP SAN unit (4) is ~~might be~~ configured [[in]]to have one or more logical volumes. Each ~~and each~~ volume, in one embodiment, is further partitioned into several portions, as shown in Fig. 5 ~~might has several partitions (Fig. 5)~~. The IP SAN unit (4) further [[also]] contains block data services and other service software modules (6). The service software module (6) is configured to~~, which can~~ communicate with distribute control management station (3) for providing ~~to provide~~ storage information and for performing ~~perform~~ storage operations. The service software modules (6), in another embodiment, are further configured to communicate ~~also communicates~~ with service software modules (9) of hosts (1) for providing ~~to provide~~ block data services for the host (1). The service software modules (6) can be implemented [[with]] by any suitable programming languages such as C, C++, Java, etc and they may employ any suitable IP based communication protocols for data transfer ~~used by service software modules (6) can be any suitable IP based protocol~~.

In one embodiment, the control management station (3) and organizes [[Multiple]] IP SAN units (4) to form the ~~are organized and formed a~~ virtual storage pool (11) ~~by control management station (3) in this invention~~. The virtual storage pool (11) may contain information relating to ~~of each IP SAN unit's~~ IP addresses, the storage volumes of the block data, their addresses and sizes ~~etc from~~ of each IP SAN unit (4)[[s]]. [[The]]A spare IP SAN unit (13 ~~of Fig. 1~~) represents a part of recovery scheme used in the central controlled distributed scalable virtual machine environment.

~~e) Fibre Channel to IP Gateway (5):~~

[[It]]Fibre channel to IP gateway (5) is a component that is configured to provide translation ~~translates~~ between Fibre Channel based protocol and IP based protocol so that Fibre Channel based SAN unit will appear[[s]] as if IP based SAN unit to the rest of the world (Fig. 1).

~~f) Fibre Channel SAN Unit (6):~~

Fibre channel SAN unit is similar [[Similar]] to an IP SAN unit (4) except it uses Fibre Channel storage control, which ~~and connection media and it~~ uses Fibre Channel protocol to communicate with other parties over the network. In addition, Fibre Channel SAN unit's ~~(6 of Fig. 2) will~~ appears as an IP based SAN unit to [[this]] the distributed virtual SAN once it connects to a Fibre Channel to IP gateway (5 of Fig.2). Therefore, to simplify the foregoing discussion, a fibre channel SAN unit [[it]] will be treated [[same]] similarly as an IP SAN unit in all of following discussion without additional comments.

~~g) Management Console (10):~~

The management console on console host (14), which has been described in pending patent of "*Concurrent Web Based Multi-Task Support for Control Management System*" by the same author. [[It]]The management console could be a commercially available web

browser or a proprietary Web browser. A web browser ~~, which~~ is able to communicate with web server software (15) on control management station (3) through a web protocol such as HTTP. The Web browser could be implemented by [[with]] any suitable programming languages such as C, C++, Java, XML, etc. In addition, the management console software module (10) could be a networked software module and/or ~~other than a~~ web browser software. In this case, any other suitable network protocols can be used instead of using web protocol such as HTTP. ~~All of these have been mentioned in section c) above.~~

To simplify the foregoing discussion, the communication path between management console (10) on console host (14) and the console support software modules (8) on control management station (3) will not further mention the role or function of web server software module (15) in this invention.

From management console (10), multiple concurrent system operations and tasks can be performed for the entire distributed virtual SAN infrastructure. There are may be one or more management consoles of distributed virtual SAN infrastructure anywhere on the net.

Fig. 2~~: This figure is~~ illustrates a portion of Fig. 1 relating to an ~~. It represents the~~ actual virtual SAN. The multiple SAN units form[[s]] a virtual Storage pool (11). The virtual storage pool (11) may contain information of each IP SAN unit's IP address, the storage volumes and their sizes, etc.

Fig. 3~~: This diagram~~ shows a protocol of virtual SAN automatic configuration and building as well as shutting down a virtual SAN ~~shutdown~~. The packet format used with this protocol is described in Fig. 4.

Fig. 4~~: This Diagram~~ shows the message format, which is used by "Virtual SAN Automatic Configuration Protocol" for sending and receiving a packet.

Fig. 5~~: This Fig. Shows the storage~~ illustrates a storage layout in an IP SAN unit, wherein the storage layout [[which]] may be further divided into multiple volumes and each

volume may be further divided into multiple partitions. Each [[The]] volume refers to a logical storage unit in this discussion and it might contain multiple pieces of storage space from multiple storage hardware media.

Fig. 6: ~~This figure actually~~ is a simplified and a portion of Fig. 1, which shows a hypothetical example of how hosts are configured to access the Storage Volume of IP SAN units ~~can being accessed by hosts~~. Where each IP SAN unit is a portion ~~units are portion~~ of virtual storage pool (11 of Fig. 2) and each host is substantially the ~~hosts are those~~ same as presented in Fig. 1.

~~**Fig. 7: The Direct Attached Storage System.**~~

Fig. 8[[:]] is a block diagram illustrating an In-Band Accessed Virtual SAN. Fig. 8 ~~This Figure~~ shows another type of virtual SAN, wherein, the actual storage data path from hosts to IP SAN units has to go through control management station.

Fig. 9[[: A]] is a Simplified Diagram of Central Controlled Distributed Scalable Virtual Machine ~~and referred as CCDSVM for brief~~. With this invention, the systems in a CCDSVM can be flexibly organized into multiple different service pools according to their functionalities[[y]]. For example, multiple IP SAN units can form a virtual SAN storage pool. The hosts of CCDSVM could form other service pools to provide services other than storage services such as video services, security monitor services, and all other services provided on Web (or net) ~~and on net etc~~.

Fig.10[[: A]] is a Simplified Diagram of Disaster Recovery Scheme of Distributed Virtual SAN Infrastructure, which includes ~~consists~~ one virtual storage pool of multiple IP SAN units and one service pool of multiple hosts. For example, ~~It assumes that~~ host 1 accesses IP SAN units 1 and 2 while host 3 accesses IP SAN units 4 and 5. Also, ~~It also assumes that~~ IP SAN unit 1 and 2 are mirrored so that they have kept the same copy of data

for host 1. The same to be true for IP SAN unit 4 and 5 with host 3. In addition, ~~it assumes that~~ IP SAN unit 3 may be [[is]] a spare unit and the host 2 could be [[is]] a spare host.

~~Detailed Description of the Invention~~

~~1: Distributed Virtual SAN Infrastructure:~~

Fig. 1 [[Shows]] shows a simplified diagram of a distributed virtual SAN infrastructure according to [[this]]the present invention. With [[this]] the distributed virtual SAN infrastructure, the distributed virtual SAN storage pool (11 ~~of Fig. 1~~) comprises one or more SAN units (4 ~~of Fig. 1~~), which may be further connected to a distribute control management station (3 ~~of Fig.1~~). The SAN units (4) [[and]] can be accessed by one or more hosts (1 ~~of Fig. 1~~) via network infrastructure (2 ~~of Fig. 1~~). The entire distributed virtual SAN infrastructure can be operated through management console (10 ~~of Fig. 1~~).

~~Virtual Storage Pool Auto Building and Initiating:~~

The virtual storage volume pool (11 ~~of Fig. 1~~) of the distributed virtual SAN infrastructure (Fig. 1) can be initiated and updated when each of the IP SAN units (4 ~~of Fig. 1~~) is ~~being~~ booted and brought to online. The virtual storage volume pool (11), in one embodiment, is ~~and can be~~ updated when at least one of [[each]] IP SAN unit[[s]] is powered down or removed from the web environment ~~being shutdown~~. ~~The~~ Fig. 3 shows the distributed Virtual SAN Automatic Configuration Protocol, which leads to the success of constructing the virtual storage pool (11 ~~of Fig. 1~~) of distributed virtual SAN infrastructure (Fig. 1) according to this invention. The following steps have described the automatic building sequence of storage volume pool of the virtual SAN based on this protocol (Fig. 3). The protocol described bellow could be IP based protocol such as SNMP, or a much simple UDP protocol (Fig. 4), or any other suitable protocols.

~~a)~~ When any of IP SAN unit (4 ~~of Fig. 1~~) such as unit (n) brought up [[to]] online, [[its]] SAN service modules (6 of Fig. 2) of the IP SAN unit (4) sends [[sent]] out a "SAN unit (n) startup" packet, as illustrated in Fig. 4, ~~(Fig. 4)~~ to distribute control management station (3 of Fig. 1). The "SAN unit (n) startup" packet ~~This message~~ could be a simple user defined UDP packet (Fig. 4) indicating a system just being powered up~~with message type of system up~~. [[This]] The message carried by the packet could also [[could]] be a SNMP trap of cold start packet, or link-up packet (4 of Fig. 1) or other short packet/message of any suitable IP protocols.

When distribute control management modules (7 of Fig. 1) of distribute control management station (3 of Fig. 1) receives IP SAN unit (n)'s message, it stores the IP SAN unit (n)'s information.

~~b)~~ After storing information of the IP SAN unit, the control management modules (7 of Fig. 1) on distribute control management station (3 of Fig. 1) sends back a "need SAN unit (n)'s storage info" packet to IP SAN unit (n) (4 of Fig. 1).

~~c)~~ When SAN service modules (6 of Fig. 1) on IP SAN unit (n) (4 of Fig. 1) receive[[d]] the packet of "need SAN unit (n)'s storage info", ~~it gets~~ they obtain the storage information on the IP SAN unit (n) (4 of Fig. 1), which may include [[includes]] the number of storage volumes, each volume's starting address (logical block address, LBA), length, and the end address (logical block address, LBA). The SAN service modules (6 of Fig. 1) then send back a packet of "unit (n) storage info", which may include [[includes]] all information obtained [[to]]from the control management station (3 of Fig. 1).

~~d)~~ After receiving the "unit (n) storage info" packet from IP SAN unit (n) (4 of Fig. 1), the distribute control management modules (7 of Fig. 1) on distribute control management station (3 of Fig. 1) update[[s its]]the stored information of virtual storage pool (11 of Fig. 1) with corresponding storage information of IP SAN unit (n) from packet.

~~e)~~ When any one of IP SAN unit (n) is shutting down, the service module (6 of Fig. 1) of the IP SAN unit (n) (4 of Fig. 1) sends a "Unit (n) shutdown" message to the distribute control management station (3 of Fig. 1). This shutdown message could be an SNMP trap of link down, or a [[much]] simple UDP packet (Fig. 4) with message type of system down, or other short packet based on some other protocols.

~~f)~~ After ~~received~~ receipt of the "unit (n) shutdown" packet from IP SAN unit (n) (4 of Fig. 1), the distribute control management modules (7 of fig. 1) on distribute control management station (3 of Fig. 1) update[[s]] information of the virtual storage pool (11 of Fig. 1), which is [[that]] specific [[for]]to the IP SAN unit (n) (4 of Fig. 1).

~~**Distributing Storage Volumes in Pool for Hosts Accessing:**~~

After one or more IP SAN units (4 of Fig. 1) are ~~brought into~~ online, the control management station (3 of Fig.1) obtains and/or stores ~~has owned~~ information [[of]]relating to storage volumes and networking protocols for [[all]] every IP SAN unit (4 of Fig. 1) in the virtual storage pool (11 of Fig. 1). Therefore, the control management station (3 of Fig. 1) is able to distributed [[distributing]] storage volumes to hosts (1 of Fig. 1) in several steps.

~~For example,~~ First, the host 1 (1 of Fig. 1) sends a request to control management station (3 of Fig. 1) requesting a storage space, such as [[needs]] 80 GB (gigabyte) of storage. Second, the control management station (3 of Fig. 1) stores host 1 information and searches for availability of 80 GB of storage volume. The control management station (3), for example, finds an 80 GB available storage volume in ~~It found the~~ volume 2 [[on]] of the IP SAN unit M (Fig. 6). Third, the control management station (3 of Fig. 1) sends the requested information of host 1 to IP SAN unit M (Fig. 6), wherein the requested information [[which]] includes the IP address of host 1[[,]] and the requested storage size. The control management station (3 of Fig.1) also sends the storage volume information [[of]] relating to the IP SAN unit M to host 1 (1 of Fig.1), wherein the storage volume information [[which]] includes the IP address of IP SAN unit M, the volume number and the size, the volume's starting address,

and volume's ending logical address block (LBA) [[etc]]. Therefore, all parties of three, namely the control management station (3) and host 1 and the IP SAN unit M, keep the same storage volume assignment information [[in sync]]. Fourth, once the host 1 (1 of Fig.1) and IP SAN unit M (Fig. 6) get each other's information, the host (1 of Fig. 1) can directly and independently access the volume 2 on IP SAN unit M immediately and the ~~right way with respect of security checking by~~ IP SAN unit M, in one embodiment, is further configured to perform security checking in light of storage accessing.

Alternatively, The[[se]] above described steps may also be semi-automatically setup with assisting of system operations performed by the [[from]] management console (10 of Fig. 1). For example, [[first]] an administrator could initially setup volume 2 of IP SAN unit M (Fig. 6) to be exclusively accessed by host 1 (1 of Fig. 1) as long as [[he]] the administrator acknowledges that host 1 needs such size of storage volume. ~~Second, the~~ The administrator can also [[can]] setup the host 1 with all information needed to access volume 2 of IP SAN unit M (Fig. 6). Finally, the host 1 (1 of Fig. 1) can access volume 2 of IP SAN unit M (Fig. 6) directly without [[goes]] going through the control management station (3 of Fig. 1).

~~**Dynamic Capacity Expanding:**~~

The present invention also discloses a mechanism of dynamically expanding storage capacity. After the distributed virtual SAN storage pool (11 of Fig.1) is initiated, the host (1 of Fig. 1) will be able to access the volume of an ~~on assigned~~ IP SAN unit (4 of Fig. 1) in the pool (11 of Fig. 1) directly without further involvement of the control management stations' ~~involvement~~ (3 of Fig. 1). This will allow the storage pool (11 of Fig. 1) of this distributed virtual SAN infrastructure (Fig. 1) to continue expanding without affecting [[effect]] any hosts (1 of Fig. 1) to continue accessing the storage volumes on assigned IP SAN units (4 of Fig. 1) in the pool. As a result, this guarantees that the distributed virtual SAN storage pool

(11 of Fig. 2) can be dynamically expanded without interrupting any normal storage operations and accessing of entire distributed virtual SAN storage pool (11 of Fig. 2).

~~**Scalability:**~~

The present invention further discloses a technique of system scalability. Once the distributed virtual SAN storage pool (11 of Fig. 1) [[being]] is constructed, each host[[s]] (1 of Fig. 1) can access one or more IP SAN units (4 of Fig. 1) in the storage pool (11 of Fig. 1) of the distributed virtual SAN infrastructure (Fig. 1) whenever it requests[[ed]]. For example, host 1 (Fig. 6) can access IP SAN unit 1, unit 2, and unit M (Fig. 6) after the host (1) requests an access to the IP SAN units and subsequently, the ~~it requested and granted by~~ control management station (3 of Fig. 1) grants the request. This effectively provides scalable storage system for each hosts (1 of Fig. 1) within distributed virtual SAN infrastructure (Fig. 1) of this invention. Further, the distributed virtual SAN infrastructure (Fig. 1) provides far better scalability than the in-band accessed virtual SAN (Fig. 8), wherein[[,]] the scalability of in-band accessed virtual SAN were severely limited by the bottlenecked control management station (Fig. 8).

~~**Storage Sharing:**~~

The present invention also discloses a method of storage sharing mechanism. Once the distributed virtual SAN storage pool (11 of Fig.1) is [[being]] constructed, each IP SAN unit[[s]] (4 of Fig.1) in the pool of distributed virtual SAN infrastructure (Fig. 1) may [[be]] hold multiple storage volumes in the form of block data, which can be accessed by [[for]] one or more hosts (1 of Fig.1) ~~accessing~~. Therefore, it [[will]] allows multiple hosts (1 of Fig. 1) to share an IP SAN unit (4 of Fig. 1) by granting and assigning each host to exclusively access particular volumes on that IP SAN unit (4 of Fig. 1). The Fig. 6 demonstrates such a storage sharing, wherein[[,]] IP SAN unit (2 of Fig. 6) has three volumes, which named volume 1, volume 2, and volume 3. The block data service modules (6 of Fig. 1) on IP SAN unit (2 of Fig. 6) allows ~~can arrange share~~ volume 1 to be accessed

exclusively by [[with]] host1 while ~~and shares~~ volume 2 to be accessed exclusively by ~~with~~ host 2 ~~exclusively~~.

~~**Performance:**~~

With in-band accessed virtual SAN (Fig. 8), the control management station could be a performance bottleneck. With distributed virtual SAN of this invention, each host[[s]] (1 of Fig. 1) can directly and independently access[[ing]] any IP SAN unit (4 of Fig. 1). Therefore, the performance of storage accessing for each host[[s]] will not be affected ~~effected~~ and can match the performance of direct attached storage system (Fig. 7) when the high speed network connecting media is deployed in the distributed virtual SAN infrastructure (Fig. 1).

~~**Centralized Management of Distributed Virtual SAN:**~~

The present invention also illustrates a method of a centralized management of distributed virtual SAN. The storage management console on a console host (10 of Fig.1) can communicate with console support software module (8 of Fig. 1) on a control management station (3 of Fig. 1). The storage management console is configured to further receive ~~and to further get~~ information relating to [[of]] all IP SAN units (4) from control management modules (7 of Fig. 1) of control management station (3 of Fig. 1). Therefore, it [[can]] provides centralized management functionality for entire distributed virtual SAN storage pool (11 of Fig. 1), hosts (1 of Fig. 1), and the control management station itself (3 of Fig. 1). With multiple concurrent tasks controlled by the ~~supporting in~~ console support software module (8 of Fig.1) of control management station (3 of Fig. 1), the storage management support console (10 of Fig.1) can provide a full range of system operations and tasks. In addition, multiple system tasks and operations can be run concurrently throughout the entire distributed virtual SAN and hosts. These management tasks include[[s]] storage configuration, storage volume allocation and assignment, storage partitioning and

repartitioning, storage, network, and other resource usage and activity ~~activities~~ monitoring[[, etc.]].

~~**Disaster Recoverability:**~~

In one embodiment, the present invention discloses a process of disaster recovery capabilities. The use of DNS or ~~may be other~~ an IP address identification mechanism helps this distributed virtual SAN infrastructure to overcome the geometric (region) limitation, and works well in a [[either]] cross network domain[[s]] environment or in a single network domain environment. Therefore, any IP SAN unit or host as well as a control management station could be anywhere on the corporate Intranet, [[on]] department LAN, or [[on]] Internet. As a result, the present invention can be used for an emergency or a disaster recovery plan because the distributed virtual SAN infrastructure increases logical range by 100 miles as oppose to the ~~it is possible to have a disaster recoverability plan goes beyond 100 miles long vs~~ traditional 10-kilometer limitation.

In addition, the disaster recovery plan of distributed virtual SAN infrastructure can be flexibly implemented as showing in Fig. 10. With this recovery plan, the host 1 or 3 (1 of Fig. 10) can continue to operate even if [[whenever]] one of its mirrored IP SAN units failed (3 of Fig. 10). Also, the spare IP SAN unit can be used to quickly replace the failed IP SAN unit whenever there is a need[[s]]. On the other hand, the hosts (1 of Fig. 10) also can be organized into a service pool for providing special services, such as [[for]] distributing video services, distributed database pool, distributed security monitor services, and all other services provided on the net ~~and on~~ or the Web. Therefore, whenever host 1 or 3 failed, the spare host can quickly take over their assigned IP SAN storage and replace them to continue providing services ~~provide service~~ to the end user.

It should be noted that the storage of any IP SAN unit can be shared and accessed by multiple hosts. To scale a virtual storage, a host may be assigned to access multiple volumes of storage capacities from multiple IP SAN units. In one embodiment, the storage accessing

goes directly through communication link between hosts and SAN units, which means that it is an out-band access. An advantage of using the present invention is that it has better performance and scalability than that[[ose]] in-band accessed virtual SAN. Furthermore, the present invention allows the virtual storage pool to expand dynamically through adding more IP SAN units into the pool without interrupting systems operation.

The implementation of web-based multi-concurrent tasks allows entire distributed virtual SAN infrastructure to be managed and monitored from a centralized console. Also, the IP based distributed virtual SAN infrastructure is a new type of central controlled distributed scalable virtual machine (CCDSVM). The software modules used in IP based distributed virtual SAN infrastructure are web-based operating system models. Furthermore, the methods and principles of the IP based distributed virtual SAN storage pool, which may automatic build and deliver storage services to the end users or clients on-demand bases. The present invention can also apply to various data distribution services within the CCDSVM infrastructure.